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(54) **METHODS AND APPARATUS FOR DETECTION SYSTEM HAVING FUSION OF RADAR AND AUDIO DATA**

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(58) **Field of Classification Search**

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,699,341	A *	10/1972	Quillinan	H04N 3/09 250/330
4,825,216	A	4/1989	DuFort	
5,703,321	A *	12/1997	Feierlein	F42B 12/36 102/427
H1916	H	11/2000	Hollander	
6,215,731	B1 *	4/2001	Smith	F41H 11/00 367/128

(Continued)

FOREIGN PATENT DOCUMENTS

FR	WO 0165197 A1 *	9/2001	F41G 3/04
NO	EP 2793043 A1 *	10/2014	G01S 3/8083
WO	WO 2013055422 A2 *	4/2013	F41G 3/147

OTHER PUBLICATIONS

P. Thumwarin, N. Wakayaphattaramanus, T. Matsuura and K. Yakoompai, "Audio forensics from gunshot for firearm identification," Information and Communication Technology, Electronic and Electrical Engineering (JICTEE), 2014 4th Joint International Conference on, Chiang Rai, 2014, pp. 1-4.*

(Continued)

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(57) **ABSTRACT**

Methods and apparatus for locating a weapon by fusing audio and radar data. An exemplary embodiment comprises detecting a weapon firing event with an audio sensor system, detecting a projectile fired from the weapon with a radar system, calculating a state vector associated with the projectile detection, identifying a location of the weapon by backtracking the state vector to the detected time of the weapon firing event time, and communicating the location of the weapon.

12 Claims, 6 Drawing Sheets